

DESIGN AND DOCUMENTATION GUIDE


FOR

TOXIC GAS HANDLING MANIFOLDS  
AND

GAS CABINETS

March 1988

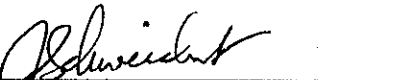
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### DESCRIPTION:

This outline guide is intended to help the designer of Gas Handling Safety Enclosures. The LLNL Documentation Guide for Pressure Equipment (Appendix 1) requires that a Safety Note or Plant Engineering Standard, and an Operational Safety Procedure be written and approved for every toxic, flammable, or corrosive system used at the Laboratory. This document provides guidance for developing systems that meets LLNL requirements.

Several gas manifold and gas cabinet manufacturers produce safe, reliable, and tested toxic gas handling systems. The designer, user, or operator must provide a detailed description and schematic for the remainder of the system from the gas enclosure to the experimental apparatus. This will be verified, tested, approved, and attached to their Safety Note to form the completed system documentation.

Safety Notes for gases require specific details as to health, reactivity, and flammability characteristics. A Material Safety Data Sheet (MSDS) for the particular gas intended for use must be attached to the Safety Note. Several individuals should review the proposed system and should be called upon to provide assistance. The area Health and Safety Team can provide support from Industrial Safety, Fire Safety, Industrial Hygiene, and Environmental Protection. The Pressure Safety Manager will support these efforts and supply an LLNL pressure inspector when needed. The area Plant Engineering Team should be contacted about blower and stack installation, and alarm-detection systems. Please see checklist, Appendix 2.

### SPECIFICATIONS:

The following requirements for a gas handling cabinet and manifold system must be satisfied in order to meet the basic Engineering Safety Note criteria for all toxic, corrosive, flammable, or pyrophoric gases.

#### The Gas Cabinet must meet the following specifications:

1. Constructed from a minimum 18-gauge steel.
2. Have a self-closing and latching door.
3. Have a self-closing window.
4. Contain a U.L.-listed sprinkler with a water supply approved by the Fire Protection Engineer in the area Hazards Control Safety Team.
5. Have a minimum face velocity across the open window of 150 feet per minute (FPM), and an average of 200 FPM. The area Industrial Hygienist must make the final determinations and verifications.
6. Must be secured (seismic consideration).
7. Must be separated according to gas compatibility.
8. All gas systems must have identification labels outside the cabinet.
9. Blower should be connected to emergency power.
10. Must be louvered at the bottom to draw air through the cabinet.
11. Must have a toxic gas leak and excess flow detector to close the emergency shutoff valve (local alarm required).

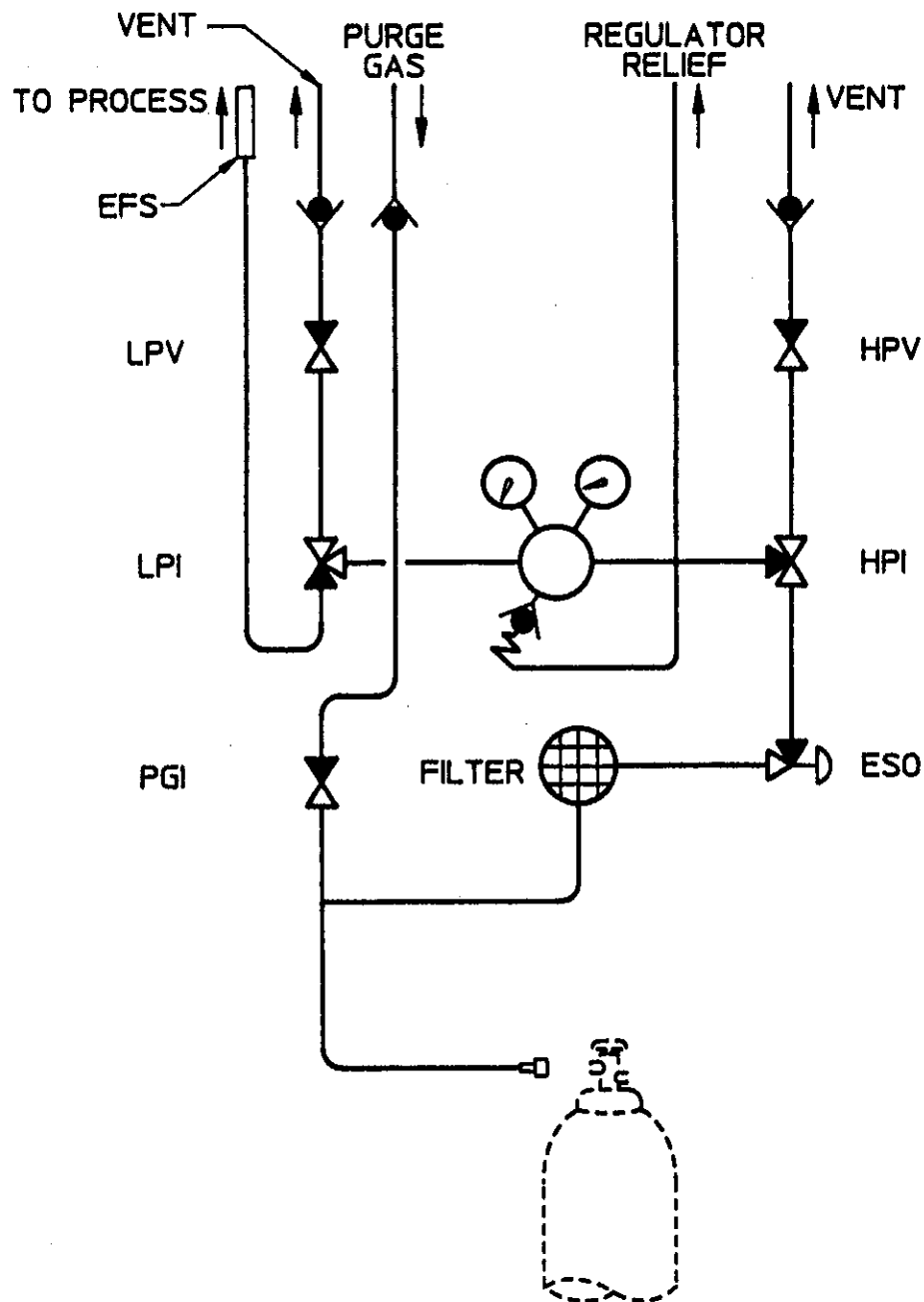
#### The Gas Handling Manifold must be equipped with:

1. "Connected poppet" (tied seat) regulator for process gases.
2. High-pressure isolation valve.
3. High-pressure vent valve.
4. Regulator overpressure relief valve.

5. Gauges readable through window.
6. Regulator bonnet relief.
7. 0.5 micrometer sintered stainless steel filter.
8. Correct Compressed Gas Association (CGA) cylinder connection.
9. Vent and purge line check valves.
10. VCR compatible fittings.
11. Butt-welded construction.
12. 316 S.S. tubing electropolished.
13. Rigid mounting of all components.
14. Modular construction.
15. Helium leak tested (certified in writing).
16. Pressure tested to 1.5 MAWP, or certified in writing by vendor.
17. Emergency shutoff (ESO) valve control located outside the gas cabinet.
18. Purge system procedure (manual required, automatic optional).
19. Excess flow switch (EFS) (the particular flow rate for the application must be specified).
20. Suitable materials compatible with the gases to be used.
21. Each vendor will have specific recommendations for the particular gas and system you intend to use--e.g., arsine, chlorine, and nitrogen trifluoride use a five manifold design (see example, Figure 1).

Gas lines must be:

1. Welded connections, unless inside exhausted enclosure.
2. Labeled with contents.
3. Have remote shutoff valves.
4. Protected and properly secured.



5 VALVE PURGE MANIFOLD W/EXCESS FLOW SWITCH  
AND EMERGENCY SHUTOFF VALVE

Figure 1.

**SEMI GAS**  
**SYSTEMS INC.**



### HAZARDS:

Determine the most credible failure modes and evaluate the typical hazards involved in a toxic, corrosive, or flammable gas system:

1. Failure of the pressure system.
2. Inhalation, eye, and skin contact hazard to personnel.
3. Venting of the toxic or corrosive substance to the atmosphere and subsequent reentry into the building ventilation system.
4. Fire and/or explosion hazard.
5. Laboratory and equipment damage.
6. Reaction between non-compatible gases.

Minimize the hazards by:

1. Verifying MAWP of system components, and using Safety Factors of 5 to 8 for toxic corrosive gas systems. The system will be provided with relief devices set to the MAWP of the system and will be pointed and vented to a safe location. All pressure components will be tested to 1.5 MAWP and witnessed by a pressure inspector or provided with vendor written verification of pressure test and leak test.
2. Inhalation hazard to personnel will be evaluated by the area hygienist. He or she will determine the adequacy of flow and ventilation required to operate the system. Exhaust specifications can be obtained from the enclosure vendor. Eye and skin contact will also be evaluated by the Industrial Hygienist.
3. Environmental releases and the requirement for scrubbing or neutralizing the vented or released material will be determined by the area hygienist and/or the environmental analyst. Stack height and reentrainment considerations will be obtained from joint Hazards

Control, Plant Engineering, and client interactions.

4. Fire hazard will depend on the particular gas used. It is recommended that a building sprinkler system and water flow alarm be provided where necessary. Smaller systems may be able to use sprinkler heads on individual enclosures. This determination will be made by the Fire Protection Engineer.
5. Laboratory and equipment damages are expensive, and many items have long lead-time delivery. The emphasis on safety, proper equipment use, and training of personnel will ensure continuous use and minimal down-time. Some minimal training should be provided by the vendor.
6. Normally only one process gas and an inert gas purge are allowed in a gas cabinet. If two or more process gases are in one enclosure, the Industrial Hygienist will determine the material compatibility and need for separation.
7. Reactive gases require careful material selection and assurances of proper cleaning and passivation procedures.

#### CALCULATIONS:

The toxic gas system will consist of tubing valves and fittings of proven reliability and compatibility with the materials used in the system. All hardware, whether vendor purchased or assembled at LLNL, will have a manned area Safety Factor of 4 or greater (5 to 8 is recommended whenever possible). This Safety Factor can be determined by vendor ratings or by the calculated stress in the component at MAWP. Manufacturers' pressure and temperature ratings will be accepted. All system components will be pressure tested to 1.5 times MAWP (unless tested and certified by the vendor). System and components will be leak checked at MAWP after successful pressure test at

1.5 MAWP. Vacuum leak check may or may not be required, as determined by the user's application and recommended practices.

#### PRESSURE TESTING:

All pressure tests require a signed Safety Note and written test procedure before testing. Pressure testing and leak checking of the gas cabinet with enclosed gas manifold panel is usually provided by the vendor. Verification of these tests should be obtained in writing from the vendor. If the tests are not performed by the vendor, then the gas manifold must be tested to 1.5 times the MAWP (relief device setting) and witnessed by an LLNL pressure inspector. The specific procedure for testing will be agreed upon by the designer, user, and an LLNL pressure inspector.

If the gas cabinet and enclosed manifold has been tested and verified by the vendor in writing, the pressure test will consist of all lines exiting the enclosure. This test will verify the lines, fittings, and joints from the enclosure to the experimental apparatus (laser, vacuum chamber, etc.). Remember that all joints or fittings of the hazardous gas line must be welded or contained in a ventilated hood or enclosure. The test procedure is the responsibility of the designer/user and must be included or appended to the Safety Note.

#### RETEST AND INSPECTION:

If any part of the system is modified, it must be retested; however, replacement of standard rated components by a qualified Pressure Installer is permissible. The normal retest and reinspection is every three years. If a shorter time span is desired, this must be specified in the Safety Note.

Normal maintenance and upkeep is the responsibility of the user. Portable systems should be tested at the High Pressure Laboratory. Field inspections must be witnessed and certified by an LLNL pressure inspector as per Health and Safety Manual Supplement 32.05, "Pressure Testing." Gas cabinet ventilation surveys will be done annually by Hazards Control.

**LABELING:**

Upon successful completion and certification of the pressure test the pressure inspector will affix the LLNL "pressure tested" label. This information should be included in the Engineering Safety Note.

LLNL PRESSURE TESTED	
ASSY.	Semi Gas Cab./Manifold
SAFETY NOTE	ENS 87-950
M.A.W.P.	200K Pa ( 30PSIG KSI)
FLUID	Nitrogen Trifluoride NF/3
TEMP.	0 TO 25 °C
REMARKS	Manned Area
TEST NO.	M.E. 1250
BY	BORZILERI
DATE	10-01-87

### ASSOCIATED PROCEDURES

Attach to the Safety Note the Operational Safety Procedure, special instructions, and a Material Safety Data Sheet (MSDS) for the hazardous gases used. Disassembly, maintenance, decontamination, and waste disposal should be considered.

### REFERENCES:

List any documents used for calculations verification, or ratings.

Examples:

1. Marks Handbook, 7th Edition (P. 4-25).
2. Health and Safety Manual Supplement 32.03, (P. 20).
3. M.E. Safety Note ENS 78-954, L.L. Dibley.
4. Semi Gas Systems, Inc., verification of pressure testing and leak check.
5. Matheson Gas Data Book, Fifth Edition.

**SIGNATURE AUTHORIZATION FOR DEPARTMENT/DIVISION:**

(required for all Engineering Safety Notes involving pressurized gas vessels or systems)

Prepared by: \_\_\_\_\_

Responsible Designer

Reviewed by: \_\_\_\_\_

Pressure Consultant

Approved by: \_\_\_\_\_

Division Leader

Approved by: \_\_\_\_\_

Deputy Associate Director\*

**REVIEW AND AUTHORIZATION FOR THE OPERATIONAL SAFETY PROCEDURE:**

The preparer submits a finished draft of the OSP to the Hazards Control Safety Team Leader in his or her area. The team leader is responsible for coordinating reviews. The degree of review and level of management required for authorization is related to the level of risk as defined in Appendix 2C, Chapter 2 of the Health and Safety Manual.

Both an Engineering Safety Note and an Operational Safety Procedure are required for toxic/corrosive gas systems. See the LLNL Documentation Guide for Pressure Equipment (Appendix 1).

\* Required for brittle materials or Safety Factors of less than 3

**AUTHORIZED INDIVIDUALS:**

Review Health and Safety Manual Chapter 32, "Pressure," for definitions and responsibilities of designers, pressure consultants, pressure installer, responsible user, and pressure operator. The document "Authorized Individuals for Pressure Work" will provide you with a list of pressure installers and pressure consultants in your area. This document is available through the Hazards Control Education Department, X2-5158, L-383, or contact the Pressure Safety Manager, X2-6076, L-384.

**STANDARD DISTRIBUTION:**

Deputy Associate Director

Division Leader

Pressure Consultant

Section or Group Leader

LLNL Pressure Safety Manager, L-384

Hazards Control Safety Team Leader

Responsible User(s)

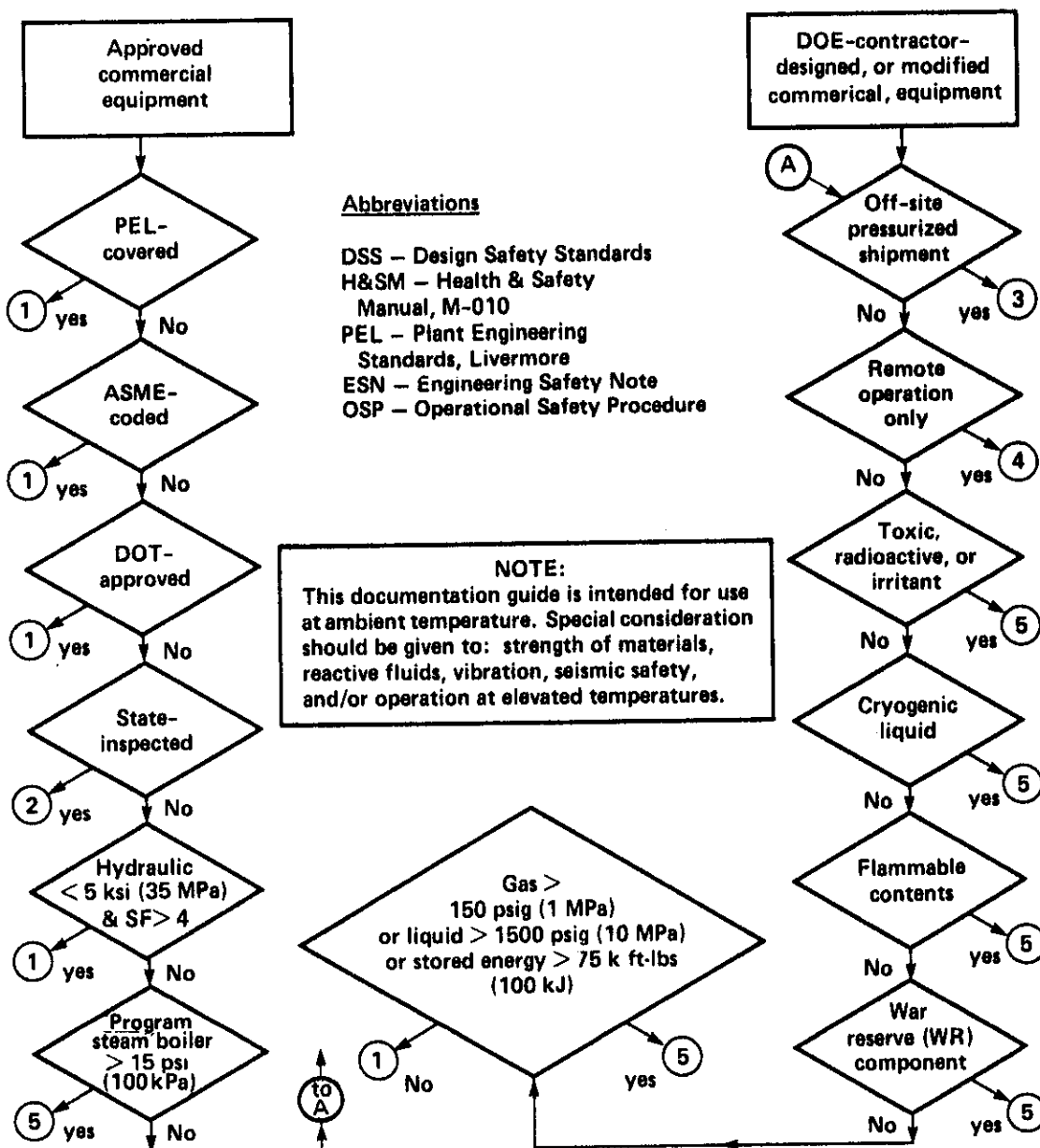
Responsible Designer(s)

(Others concerned, including building coordinator)

M.E. Department Library, L-129 (Permanent Repository)

# Appendix 1

## LLNL Documentation guide for pressure equipment



9/87



APPENDIX 2  
TOXIC GAS SYSTEM FINAL CHECKLIST

1. Have you contacted the following individuals or groups to review initial planing and followup throughout the process?
  - A. Hazards Control Heath and Safety Team Leader in your area.
  - B. Pressure Safety Manager.
  - C. Plant Engineering team in your area.
2. Have you listed your designer, users, operators, and their respective training?
3. What specific training should be required for the system, i.e. laser safety, pressure training, capacitor training?
4. Have you obtained the proper MSDS for the gases and chemicals you expect to use, and attached them to your Engineering Safety Note and Operational Safety Procedure?
5. Does the gas cabinet and manifold meet all the requirements of this guide? If not, specific exemptions and appropriate sign-off authority must be established.
6. Have you obtained all operating, purge, passivation, disassembly, and disposal procedures, or any other special operating or maintenance procedures from the vendor?
7. Have you listed all the hazards, consequences of the hazards, and the specific steps you have taken to minimize or eliminate these hazards to personnel, facilities or equipment?
8. Have you verified Safety Factors and equipment ratings?
9. Do you have written verification of vendor-performed leak test, pressure test, etc.?
10. Has the remainder of the system been pressure tested and leak tested? Pressure test must be witnessed by a certified Pressure Inspector.
11. Has the fire sprinkler head been connected to a water supply approved by Hazards Control Fire Protection Engineering Group?
12. Has the LLNL "Pressure Tested" label been affixed to the system before use?
13. Has the Operational Safety Procedure been approved and signed?
14. Has the Engineering Safety Note been approved and signed?

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